In order to determine to what degree lapse rates obtained by means of thermometers at different heights above deck are useful, the wet and dry bulb temperature at different heights on days when an Assmann calibration with the Hartmann and Braun thermometers was made, were plotted. These daytime lapse rates are shown in Figure 8. The most striking fact is that these rates are decidedly superadiabatic.

(1) July 29, 1928, at 12^h local mean time, off coast of Iceland: The dry bulb at the masthead was 1°.5 C. lower than the deck dry bulb, a lapse equal to four times the dry adiabatic. The wet bulb lapse was 1°.1 C. between deck and masthead or six times the saturated adiabatic. The weather was cloudy with a moderate NW. breeze, sea moderate with surface temperature of 11°.6 C.

2) January 14, 1929, at 10^h local mean time, entering the port of Callao: There was a dry bulb temperature lapse of 2°.1 C. from deck to crosstrees and of 0°.5 C. from crosstrees to masthead, a total lapse of 2°.6 C. in 35 meters or seven times the dry adiabatic. The wet bulb lapse rate was 1°.0 C. between deck and crosstrees or nine times the saturated adiabatic. Wind was SSE., force 3, weather cloudy, sea temperature 18°.8 C.

(3) March 12, 1929, at 11^h local mean time, approaching the island of Tahiti: The dry bulb lapse rate was 2°.0 C. from deck to crosstrees and 0°.8 C. from crosstrees to masthead, a total of 2°.8 C. or seven times the dry adiabatic. Wet bulb lapse was 1°.1 C. in 35 meters or six times the saturated adiabatic. Weather was squally with gentle NW. breeze. Sea-surface temperature was 28°.3 C.

If the deck readings are ignored the lapse rates between crosstees and masthead are respectively two, four, and six times the dry adiabatic. These are exceedingly steep, suggesting that even the crosstree temperatures may have been affected by radiation from deck, sails, and shelter. It is entirely possible that such lapse rates could exist—rates as high as ten or twenty times the dry adiabatic have been observed. Certainly these excessive lapse rates do not represent actual air conditions over the entire ocean for any length of time. It would seem impossible for such unstable conditions to exist throughout a layer of air 35 meters thick for any length of time over any great area.

The results of the study of air and sea temperatures obtained on the *Carnegie* indicate that it is possible to obtain entirely satisfactory sea-surface temperatures with the sea thermograph corrected by careful bucket readings. It seems very probable, however, that air temperatures obtained on a ship at sea, particularly in the summer or in the tropics are too high and do not represent actual conditions over the sea. Since differences between sea and air temperatures are usually less than 1° C., for purposes of studying the physical processes of the atmosphere it becomes necessary to have air temperatures accurate to a tenth of a degree. In order to obtain temperatures of such degree of accuracy methods must be devised for obtaining these continuous temperatures free from the effect of local heating. *Carnegie* data indicate that if air temperatures a few meters above the sea, free from the effects of insolation on the shelter, radiation and heated air could be obtained, it would be found that even the mean hourly air temperatures seldom exceed the sea temperatures. Certainly the sea experts a powerful temperature influence upon the atmosphere.

THE SELECTED-SHIP PROGRAM FOR OCEAN-WEATHER REPORTING BY RADIO

By EDGAR B. CALVERT, Chief, Forecast Division.

[Weather Bureau, Washington]

During the past two years the Weather Bureau has been actively engaged in furthering its share of a project, international in scope, intended to coordinate and improve the work of reporting meteorological conditions at sea by radio. It is not intended that the new scheme, so far as the bureau's own service is concerned, shall supersede the existing arrangement through which it secures by radio, chiefly for its own purpose, a considerable daily collection of reports from ships in the Pacific Ocean and during the hurricane season from ships in the South Atlantic, Gulf of Mexico, and Caribbean Sea. Though the new project is distinctively international in character and is the Weather Bureau's contribution to a world-wide program, it will serve to strengthen materially its own radio weather service from ships at sea.

Weather reports from ships have long been used in advancing knowledge of ocean meteorology and in supplying information concerning storms and other atmospheric conditions over the oceans for the benefit of navigation. In the last quarter of a century ships' weather reports have been collected by radio in increasing numbers, thereby enabling meteorological services to extend daily synoptic charts over the oceans and provide daily forecasts and warnings and synoptic weather information by radiobroadcast for use of ships at sea.

HISTORICAL

A majority of ocean-going vessels traverse waters from which weather reports are needed by the meteorological services of two or more nations. To make weather reports from a ship available to more than one meteorological service, a system of international exchanges must be set up or officers of ships are charged with much additional work in taking observations and forwarding reports to each service separately.

The need of coordination has long been recognized. More than 50 years before the invention of wireless communication, Lieutenant Maury sought more effective cooperation in ocean meteorological work. He attended the First Meteorological Congress in Brussels in 1853, and advocated the establishment of a uniform mode of making nautical and meteorological observations on board vessels of war. The result was that this conference undertook to use a uniform system of meteorological observations both on land and sea all over the world. High honors were bestowed on Maury both in this and other countries because of his work in the fields of oceanography and meteorology, but many may not remember that in 1868, he was appointed professor of meteorology in the Virginia Military Institute at Lexington, which possibly was the first recognition in this way of the science of meteorology by any institution of learning.

Development of wireless communication early in the present century brought many serious complications that did not enter into the program conceived by Maury.

The first wireless message received by the Weather Bureau containing a weather observation from a ship at sea was in December, 1905. Radio weather service from ships at sea was thereafter extended by the Weather Bureau and the weather services of other countries, keep-

ing pace with the installation of radio apparatus on ships. Such reports are now being received by the Weather Bureau at a rate in excess of 50,000 a year.

In order that a weather observation by radio may be promptly handled, a code is necessary. A coded message is much shorter, more economical in communication costs, can be transmitted with greater speed, and is handled more effectively in charting and rebroadcasting. Many different codes came into use, each meteorological service requesting information suited to its particular needs and utilizing a code best adapted to its own requirements.

Another difficulty was that each national weather service desired observations taken at hours most favorable for its daily routine of charting reports and issuing forecasts and information. The result was that officers of a ship traversing extensive oceanic areas were called upon to take observations at various hours, to forward reports by radio in different codes, and to record the observations on forms devised by each service, no two exactly alike.

The collection of ship reports and rebroadcasting of them for the benefit of marine and other interests, as well as international exchanges of reports by radio, were greatly complicated by the diversity of codes in use.

Early in the year 1928, Charles F. Marvin, chief of bureau, and Edgar B. Calvert, chief of the forecast division, representing the Weather Bureau, participated in conferences held in Paris and London for the purpose of working out a more definite and effective program of cooperation. The meetings were attended by officials of the meteorological services of the principal maritime nations of Europe. An agreement was reached whereby each country will arrange to engage a certain number of ships of its own registry on which observations will be taken daily at fixed hours and transmitted by radio. Ships are to be selected from those equipped with standard meteorological instruments and long-range radio apparatus. The number of ships of each nation engaged in the project will be in proportion to that nation's total tonnage of vessels over 100 tons. This program was adopted by the International Meteorological Organization in a conference at Copenhagen in September, 1929,at which Mr. Calvert was the Weather Bureau's representative.

Under the selected-ship plan there will eventually be 1,000 selected ships of all nations sending radio reports regularly during voyages at sea. Of this number about 225 will be of United States registry. These ships are specially selected from those having standard meterological instruments, long-range radio apparatus, and plying routes that are calculated to yield a satisfactory daily distribution of reports from the oceans.

The hours of observation of all selected ships will be identical in all parts of the world—midnight, 6 a. m., noon, and 6 p. m., Greenwich mean time, a latitude of one hour either way being allowed to meet exceptional conditions. Ships having enough watch officers may forward all four observations daily, but on most vessels only two will be radioed, giving preference to midnight and noon, Greenwich mean time.

Ship reports received at certain designated shore radio stations are exchanged by means of collective broadcasts of land and ocean reports in accordance with standard schedules. Meteorological reports are thus made available for mapping and forecasting purposes in many parts of the world within a short time after the observations are taken.

One of the most important features of the plan is that all ships' weather reports will be radioed in the same code, regardless of the nationality of the vessel sending the report or of the meteorological service to which the report is addressed. The essential portion of this standard international code, in groups of figures, with five figures in each group, is universal and invariable but each meteorological service has the choice of additional standardized groups to suit its peculiar requirements. The difficulty in securing adoption of a standard code acceptable to all meteorological services was one of the most serious obstacles in the way of coordination.

The scheme provides that selected ships of United States registry will send reports through foreign radio stations to European services when in the eastern Atlantic and selected ships of foreign registry will send reports to the Weather Bureau through United States coastal stations when in the western Atlantic. A vexing and difficult problem in the international program which concerned the payment of ship to shore tolls on these weather messages has been solved by the generous cooperation of the Radio Marine Corporation and the Mackay Telegraph & Radio Co., in the waiving of ship to shore tolls, regardless of whether the messages are transmitted to United States or foreign shore stations.

PROGRESS

Under an initial appropriation made specifically for the purpose, the Weather Bureau began in 1929 to engage ships in its North Atlantic selected-ship service. The number of United States ships so engaged is now 30. A code book for United States selected ships containing the new international code was issued in May, 1930. The work is done on a cooperative basis and the service is maintained in an efficient manner by frequent personal visits to the ships when in port by Weather Bureau representatives specifically assigned to that duty and by written acknowledgments of service performed. Similar progress has been made by other national meteorological services and radio reports from selected ships of other nations are now being received daily by the Weather Bureau.

Arrangements for international exchanges of ships' weather reports are being perfected. The Weather Bureau transmits twice daily in a radio bulletin for the benefit of European meteorological services, about 100 land station reports representative of weather conditions in the United States, Canada, Alaska, and the West Indies, and a selection of reports from ships in the North Atlantic and Pacific Oceans, the Gulf of Mexico, and the Caribbean Sea. The British Meteorological Service has recently begun transmission to the Weather Bureau of twice-daily bulletins of a similar character containing ship reports as well as observations from representative European land stations to the Weather Bureau. All these broadcasts are now in general conformance with the international codes adopted in Copenhagen in 1929.

Supplemental appropriations have been secured for extension of the selected-ship service to the South Atlantic, Gulf, and Caribbean waters during the fiscal year beginning July 1, 1931. By this means, daily reports from ships in southern waters will be received by radio throughout the year, whereas in the past such observations for the most part have been forwarded by radio only during the hurricane season. It is hoped that appropriations will become available in future years for similar service in the Pacific.